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OPERATION OF DESCENT MODULE OF THE MARS-6 AUTOMATIC INTERPLANETARY STATION IN THE MARTIAN ATMOSPHERE

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16 Abstract The Mars-6 automatic interplanetary station was launched on 5 August 1973, reaching the vicinity of Mars on 12 March 1974. At $12^h05^m53^s$, the descent module entered the Martian atmosphere at the velocity 5600 m/sec. After aero-dynamic braking on attainment of ~600 m/sec at $12^h08^m32^s$, the parachute system was activated. The descent module of the Mars-6 AIS reached the Martian surface at $12^h11^m05^s$ in a region with nominal coordinates 23.9° S. lat. and 19.5° W. long. The descent period, from atmospheric entry and aero-dynamic braking to parachute-assisted descent -- took 5.2 min.

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OPERATION OF DESCENT MODULE OF THE MARS-6 AUTOMATIC INTERPLANETARY STATION IN THE MARTIAN ATMOSPHERE

S.S. Sokolov, V.G. Fokin, V.P. Burtsev, R.S. Romanov, M.K. Rozhdestvenskiy, V.P. Karyagin, N.F. Borodin, V.F. Ivannikov, V.I. Shkirina, L.V. Nikolayenko, V.V. Kerzhanovich, and B.B. Kotov

The Mars-6 automatic interplanetary station (AIS) launched 5 August 1973 reached the vicinity of Mars on 12 March 1974. /9*

Along the approach to Mars at a distance of ∿46,000 km from the planet, at 8 hours 0.1 min 56 sec[1], the descent module (DM) was separated. By means of the engine the descent module was transferred to a trajectory of approach to Mars. Here the orbital module (OM) continued its flight along the flyby trajectory with a minimum distance from the planetary surface of about 1600 km.

At 12 hours 05 min 53 sec, the descent module entered the Martian atmosphere at the velocity 5600 m/sec. After aerodynamic braking on attainment of a velocity of ∿600 m/sec at 12 hours 08 min 32 sec, the parachute system was activated. The descent module of the Mars-6 AIS reached the surface of Mars at 12 hours 11 min 05 sec in a region with nominal coordinates 23.9° S.lat. and 19.5° W.long. (see Fig. 2 on text page 6 [of this journal issue]).

The entire section of the descent -- from atmospheric entry and aerodynamic braking to the descent by parachute inclusively -- occurred as per the program and lasted 5.2 min.

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[1] Here and in the following the Moscow time of signal reception on Earth is given.

* Numbers in the margin indicate pagination in the foreign text.

Over the section of motion up to atmospheric entry and during motion in the atmosphere of the planet Mars, data relayed directly to Earth were sent via radio telemetry signals.

The radio complex of the DM functioned from the moment of activation of the parachute system to the end of the flight. Transmission of the signal halted in ∿150 sec from the moment the DM radio complex was turned on (near the surface).

During the descent data on g-loads along the section of aerodynamic braking, pressure, atmospheric temperature, and altitude above the surface for parachute motion were obtained; Doppler measurements were also made of the DM velocity relative to the orbital module over the section of motion after staging and up to the end of the flight [1].

1. Brief Description of Descent Module

The descent module (Fig. 1) was equipped with systems and devices ensuring separation of the craft from the orbital module and also a soft landing on the Martian surface [2].

Design-wise, the craft was a rigid coupling of the main components: the automatic Martian station, the instrument-parachute container, and the aeroshell. The upper part of the module housed a connecting frame joining the descent /10 module with the orbital module. The frame housed the engine for DM separation and the installations of a number of systems.

The instrument-parachute container was installed directly in the upper part of the Martian station. It housed the drogue and main parachutes, the engine for deploying of drogue parachute, and the soft-landing retro-engine, the antennas of the radio altimeter, the antennas for communication with the orbital module, and some of the scientific instrumentation.

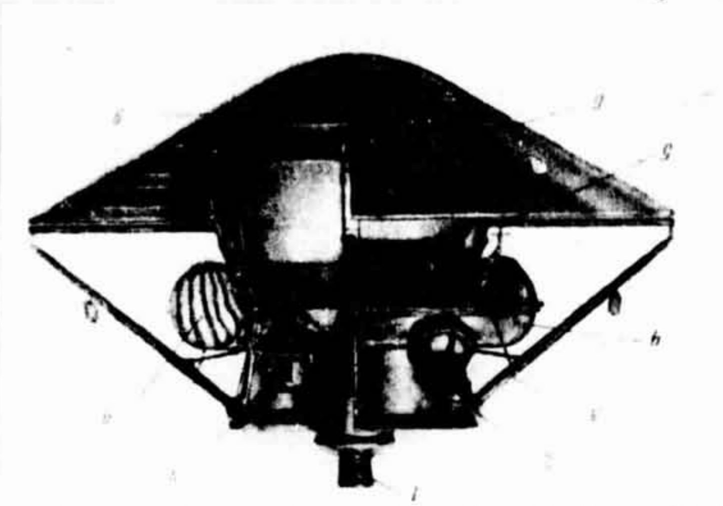

Fig. 1. Descent module of the Mars-6 AIS: 1. Engine for separation of descent module; 2. engine for deploying of drogue parachute; 3. antennas for communication with orbital station; 4. parachute container; 5. radio altimeter antenna; 6. aeroshell; 7. instruments and equipment of automatic control system; 8. main parachute; 9. automatic Martian station.

The automatic Martian station is a hermetic instrument module which includes the blocks of the onboard craft systems (radio telemetry complex, control systems, thermal regulation system, and power supply) and the scientific instrumentation blocks. Externally the scientific instruments with their extraction mechanisms were installed, along with the radio complex antennas and the system of station guidance to the working position after landing.

To the lower part of the station was secured the aeroshell, serving to slow the velocity during atmospheric entry and to protect the craft against aerodynamic and thermal loads during braking. The craft rotating engines were installed on a circular frame of the cone base, to stabilize the craft before atmospheric entry, along with engines for stopping rotating during atmospheric entry.

The necessary sequence of operation of the DM systems was ensured with a program-timing device. The structural members of the aeroshell, parachutes, and soft-landing engine were selected on the condition of minimum weight and their reliable operation over a wide range of possible descent conditions and Martian atmospheric characteristics.

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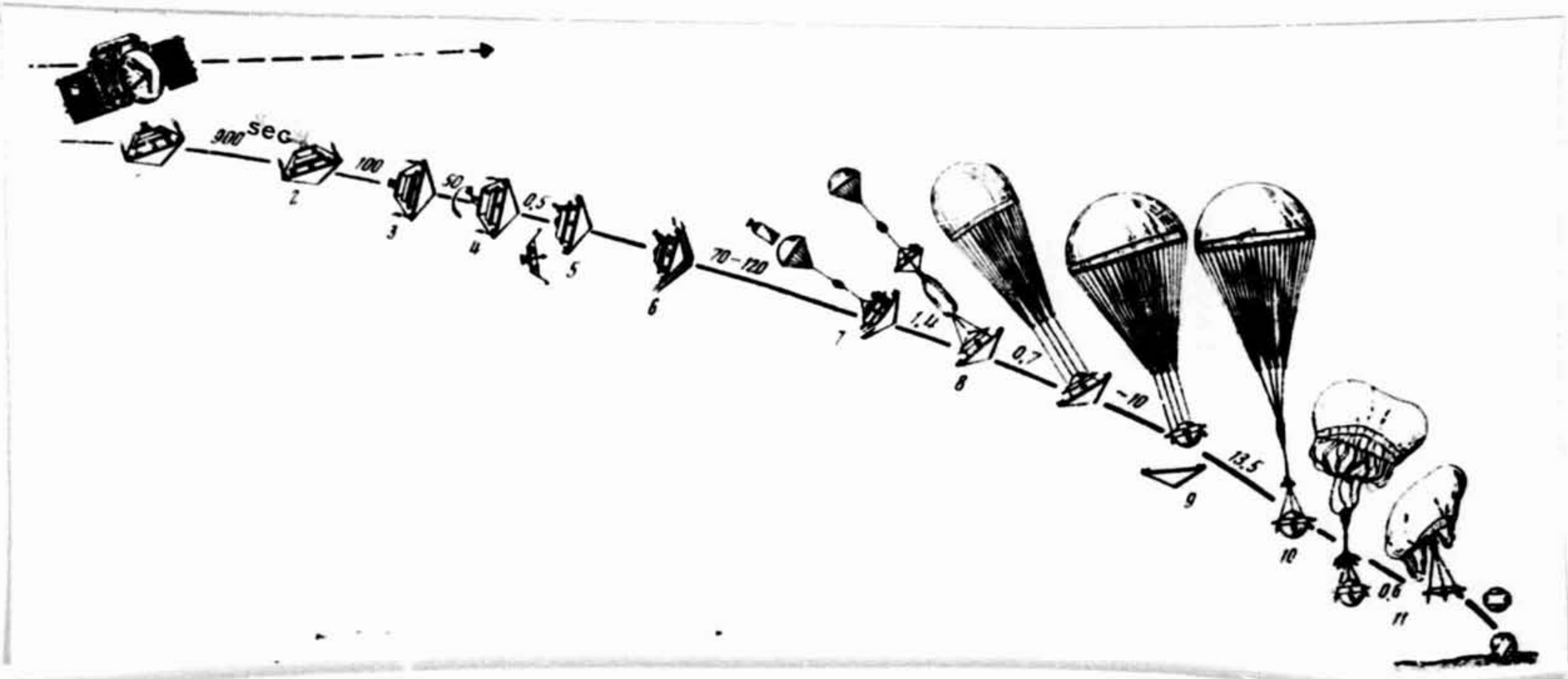

Fig. 2. Descent of DM in the Martian atmosphere: 1. staging of DM; 2. firing of solid-propellant rocket engine [SPRE]; 3. programmed turn of DM; 4. twisting of DM; 5. separation of truss; 6. end of twist, supply of power to radio altimeter [RA]; 7. beginning of deployment of parachute system [PS], triggering of program-timing mechanism [PTM], and powering of scientific instrumentation; 8. deployment of main parachute, triggering of telemetry [TM], program-timing device [PTD], radiation monitor [RM], and scientific instrumentation; 9. defluting of parachute, separation of aeroshell and firing of high-altitude radio-altimer [HARA]; 10. release of mounting of retro-engine [RE] and refastening of PS; 11. firing of retro-engine and end of transmission to orbital module [OM].

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The onboard radiofrequency complex of the DM together with the corresponding equipment on the OM of the Mars-6 station made possible reception and relaying to Earth of scientific and telemetry data during the parachute descent, as well as information on the operation of onboard systems and the motion of the DM over the entire section of the flight from the moment of separation to landing.

During the descent of the DM in the atmosphere, the following equipment functions: /12

a) temperature and pressure meter. Membrane manometers and resistance thermometers served as the sensors of pressure P and temperature T. The range of temperatures measured over the descent section is -150 to +50°C with a root-mean-square [rms] measurement error of ±5% of the total scale. The pressure sensor was designed for a measurement range 0-12 mbar, with an rms error of ±5% of the measurement scale in the -20 to +53°C temperature range;

b) a mass spectrometer whose function included determining the chemical composition of the near-planetary layer of the atmosphere;

c) a g-load meter, whose composition included a sensor and a memory device. The range of g-load measurement was +32 to -4 units. The total measurement error at maximum g-load was ±0.2% of the measurement range, which corresponded to ±0.45 unit. The instrument recorded the moments that specified g-loads are reached, the maximum g-load, and the instant of time corresponding to it; and

d) information on the instantaneous altitude over the section of the parachute descent was provided with the high-altitude radio altimeter (HARA).

2. Operation of Descent Module

The motion of the DM after its staging from the orbital module of the Mars-6 station was divided into the following sections (Fig. 2).

a) Extra-atmospheric section. Before the descent module stages from the orbital module, the final correction and turning of the station were carried out in the near-planetary communications session. Roughly 10 min before staging a radio system was activated, which transmits to the orbital module telemetry data on the functioning of the onboard equipment of the DM. This system monitored the attitude of the DM, angular velocities, power levels of transmitters, and other service parameters of the DM. After staging, a programmed turn of the descent module was effected to provide the oriented atmospheric entry with minimum angle of attack and a twist of the DM to stabilize its motion.

b) Motion of DM in planetary atmosphere. The entry of the DM into the planetary atmosphere was an oriented entry, with a near-zero angle of attack.

The design entry conditions were these: $H_{en} \approx 100$ km, $V_{en} = 5600$ m/sec, and $\theta_{en} = -14 \pm 4°$.

On entering the atmosphere, the DM effected a ballistic descent, carrying out deceleration by means of a bow shield (cone).

On attaining the longitudinal g-load $n_{x=-2\pm0.5}$, the twist of the DM stopped (by means of engines). Simultaneously, power was fed to the radio altimeters, the memory of the g-load meter, the triggering of the radio telemetry system for monitoring motion was repeated, and a sensor subsequently generating a signal for deployment of the parachute system was activated. After passing the peak g-load when the sensor was triggered, a cascaded parachute system was activated (a drogue, then the main parachute, initially fluted). During this time the scientific instruments were switched on along with the program-timing mechanism of the landing control system (PTM).

The design altitude of parachute system (PS) deployment, as a function of angle of atmospheric entry, was in the range $H = 5\text{-}10$ km (for the design atmospheric model $P_0 = 5$ mbar, $T = 210°K$). The angle of inclination of the trajectory was [symbol not given] $_{ps} = -20°$ to $-18°$.

Further operation of the DM systems along the parachute descent section was effected by commands of the PTM all the way until the soft-landing engine is fired.

After deployment of the parachute system, the gravitational turning of the trajectory occurs. The rate of descent by parachute was within the range $V_{ps} = 55\text{-}70$ m/sec by the moment the soft-landing engine was triggered, with reference to the scatter ranges of all the initial characteristics. The firing of the soft-landing engine occurred by command of the low-altitude radio sensor directly at the surface. The release of the engine from the AIS occurred on attaining the normal descent velocity $\dot{H}_{rel} = -6.5 \pm 1.7$ m/sec. The parting of the separated parts was effected with the soft-landing engine. /13

The automatic Martian station after release was in free fall from the altitude $H_{rel} = 1.5\text{-}7$ m onto the surface of the planet. The rate of craft collision with the surface (along the normal to the surface) did not exceed 12 m/sec. In landing, this velocity was taken up by shock absorbers.

Analysis of data obtained. The angle of the trajectory during atmospheric entry at the altitude $H_{en} \approx 100$ km was $\theta_{en} = 11.7 \pm 1.5°$. /14

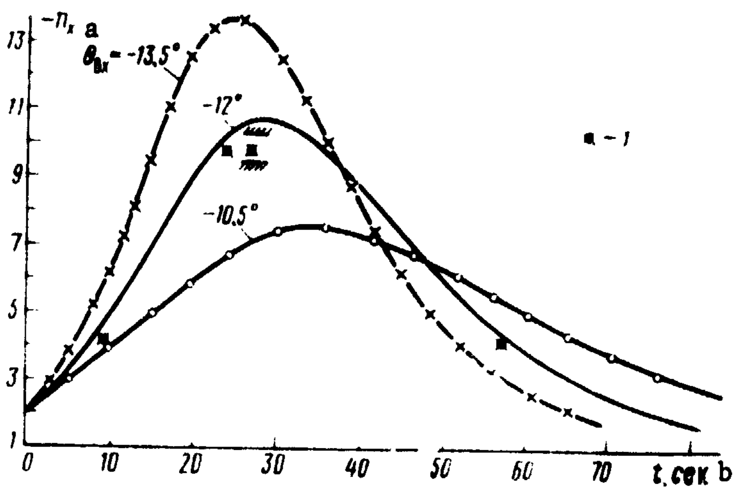

Fig. 3. Longitudinal g-loads in descent in the Martian atmosphere (in Earth units). Calculation for the atmospheric model with P_0 = 5 mbar. 1. Measurements.

Key: a. θ_{en}
b. t, sec

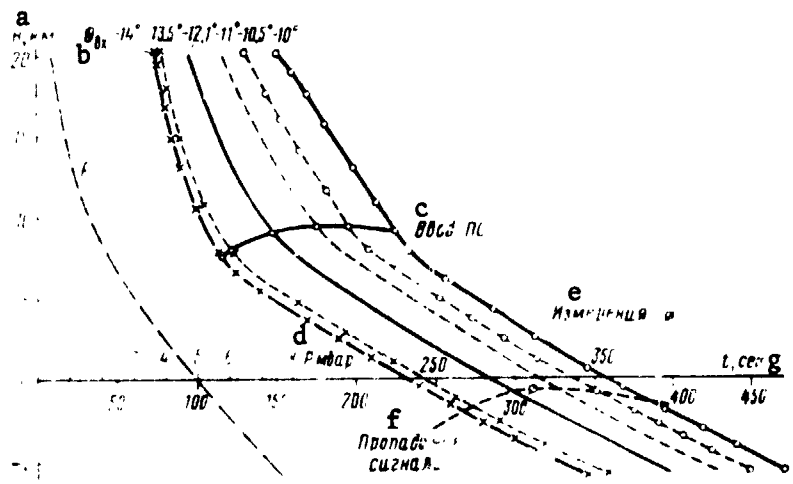

Fig. 4. Total descent time from moment of entry into planetary atmosphere.

Key: a. H, km
b. θ_{en}
c. Deployment of parachute system
d. P, mbar
e. Measurements: Ø
f. Loss of signal
g. t, sec

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The measured longitudinal g-loads obtained by the memory fitted quite closely onto the calculated g-load curve with $\theta_{en} = -12°$ obtained for the assumed calculated model of the planetary atmosphere with $P_0 = 5$ mbar and $T_0 = 210°K$ (Fig. 3). This affords grounds to employ this atmospheric model in subsequent analysis.

From the Doppler measurements we have:

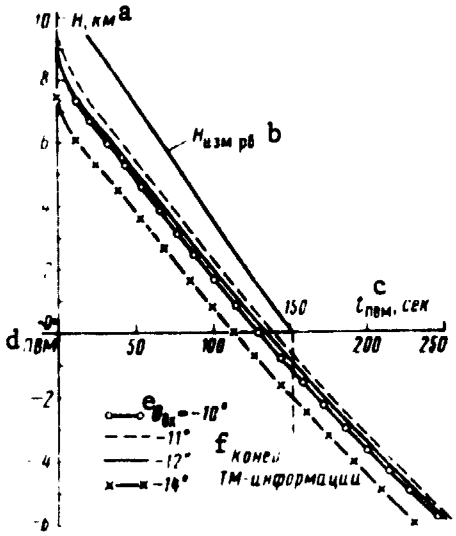

Fig. 5. Time of descent of DM on parachute.

Key: a. H, km; b. $H_{measured}$ by radio altimeter; c. t_{PTM}, sec; d. PTM; e. θ_{en}; f. end of telemetry data

the instant of signal loss due to the appearance of plasma was at 12 hours 06 min 19 sec,

the moment of signal appearance was 12 hours 07 min 32 sec,

the moment of parachute system deployment was 12 hours 08 min 32 sec and

the moment of loss of signal near the surface was 12 hours 11 min 05 sec.

Thus, total descent time in the atmosphere from Doppler measurements was $\Delta t_D = 312$ sec [D = Doppler].

The calculated time of descent with reference to the indicated possible scatter ranges of the entry angle ($\Delta\theta_{en} = \pm 1.5°$) for the calculation atmospheric model $P_0 = 5$ mbar is $\Delta t_{cal} = 270\text{-}350$ sec (Fig. 4). Here, to balance the flight and calculated descent time it must be stated that the landing of the automatic Martian station occurred in an area that was depressed

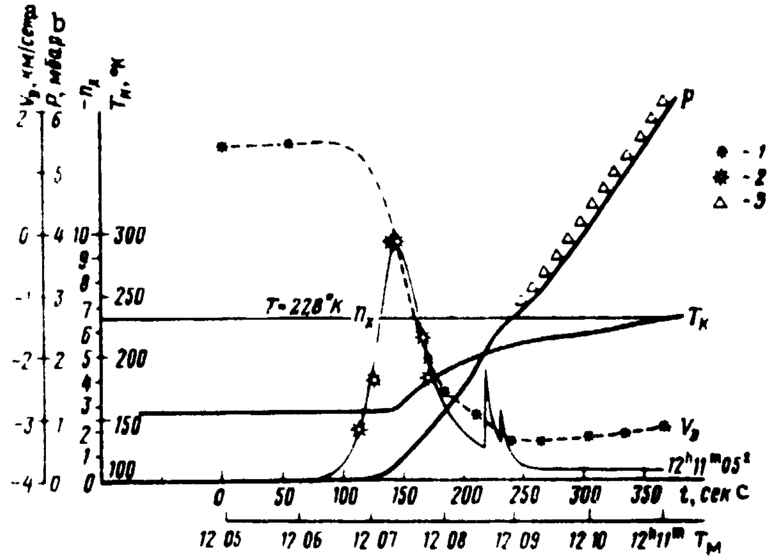

Fig. 6. Complex analysis of calculated and measured values over the descent section of the DM of the Mars-6 AIS. 1. Measurements of V_D; 2. measurements of n_x; 3. measurements of P.

Key: a. V_D, km/sec
b. P, mbar
c. t, sec

relative to the provisional zero calculated surface level (ba on the P_0 = 5 mbar model) by $\Delta H \approx -1000$ m, that is, the press at the landing site must be $P_0 \approx 6$ mbar.

Telemetry data obtained from the descent section by parachute went on for 149.22 sec. The total descent time by parachute, beginning from the moment that the signal to deploy the parachute system ("0" of the PTM) was sent, was Δt_{totPS} = 151.6 sec. /15

Comparison of the experimental descent time by parachute with the calculated time (Fig. 5) shows that the craft landed at a surface that was $\Delta H \approx -750$-2000 m below the calculated zero level (5 mbar), with pressure $P_{0\ exp}$ = 6 ± 0.5 mbar.

These conclusions, obtained from measurements by the Doppler system and telemetric data from the parachute section, were confirmed by readings of the high-altitude radio altimeter.

A complex analysis of all the information obtained from the DM affords a conclusion both on the calculated nature of the descent as well as on the parameters of the Martian atmosphere in the area of the descent of the DM of the Mars-6 (Fig. 6). As a result of these calculations, in which the calculated curves of pressure $P(t)$, g-load $n_x(t)$, altitude $H(t)$ and Doppler velocity $V_D(t)$ were brought into agreement with measurements with tie-in to instantaneous time, it was found that an atmosphere with the following parameters satisfies this tie-in of calculations and measurements:

temperature near surface -- $T_0 = 230°K$
temperature gradient -- $\gamma = 2.5°/km$ and
pressure at calculated surface -- $P_0 = 5.9$ mbar.

It should be noted that the results of analyzing the descent of the DM of Mars-6 in the Martian atmosphere presented here are preliminary and are subject to revision.

REFERENCES

1. Avduyevskiy, V.S. et al., Kosmich. issled. 13(1), 21 (1975).

2. Pravda, No. 353 (19496), 19 December 1971.

3. Rabochaya model' atmosfery Marsa [Working Model of Martian Atmosphere], preprint of the Institute of Space Research, USSR Academy of Sciences, 1973.